



Rodríguez-López, R. (2016). Environmental enrichment for parrot species: Are we squawking up the wrong tree? *Applied Animal Behaviour Science*, 180, 1-10.  
<https://doi.org/10.1016/j.applanim.2016.04.016>

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[10.1016/j.applanim.2016.04.016](https://doi.org/10.1016/j.applanim.2016.04.016)

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### Highlights

- A review of the published studies on environmental enrichment for parrots was performed.
- The literature is dominated by studies implementing more than one type of environmental enrichment in their methodologies. Physical and foraging opportunities are the most recurrent.
- Existing research on parrot well-being has analysed abnormal behaviours such as feather picking and stereotypies.
- Enrichment for parrots, and captive wildlife in general, should go beyond the modification of activity budgets: appropriate challenges considering both species' and individuals' history should be provided.

Environmental enrichment for parrot species: are we squawking up the wrong tree?

Rogelio Rodríguez-López <sup>ab</sup>

<sup>a</sup>University of Bristol. School of Veterinary Sciences. Langford House, Langford, Bristol, UK BS40 5DU.

<sup>b</sup>Bristol Zoo Gardens. Clifton, Bristol, UK, BS8 3HA.

+44 7429082763 rogelio.rodriguez@bristol.ac.uk

## Abstract

Parrots are kept in captivity as part of zoological collections and as household pets for conservation and companionship reasons respectively. The intelligence, longevity and behaviour characterising parrots increase concerns for their well-being. Appropriate husbandry practices and veterinary care are elementary practises to ensure positive well-being. However, environmental cues and living conditions might influence the animals' behaviour. Research on abnormal behaviours in parrots has focused on fear, stereotypies and feather-picking. Environmental enrichment is used as a tool to prevent abnormal behaviours and discourage inactivity. Nonetheless, there is no definite agreement on the exact mechanisms or procedures to properly improve on animal well-being but there is a generalised conception that environmental enrichment should improve on living conditions. Enrichment studies in undomesticated animals appear biased towards non-avian species. For parrots, published research focuses on one of two directions: analysing options to diversify feeding behaviour or determining preferences for objects or object characteristics. Searching the available literature resulted in finding 23 studies describing the provision of environmental enrichment to parrots. These articles were classified in one of six different categories: social enrichment if tests included interaction with other parrots or with humans as the dependent variable; occupational enrichment if the birds' behaviour was targeted without the use of food as a reward; physical enrichment if the living environment of the birds was

modified in terms of size or available furnishings; sensory enrichment if sight, audition, tact or smell were influenced; nutritional enrichment if food was involved in experimental procedures either by food type or delivery methods or mixed enrichment if two or more of the previous enrichment categories were clearly identified as part of the methodology. Literature on psittacine enrichment appeared dominated by studies targeting foraging behaviours as well as object preference. Variables such as sample size and experiment duration also presented high variability among experiments, complicating results comparisons. Giving animals something to do will have an effect on their active time but enrichment should go beyond this objective and be of biological significance, including appropriate challenges to promote well-being. Research on environmental enrichment and well-being should implement multiple indicators to increase validity.

## **Keywords**

Parrots, Environmental enrichment, Well-being

## **1. Introduction**

Psittaciformes, members of the aves class commonly known as parrots, form three predominant groups: New Zealand parrots, cockatoos and all other parrots (Joseph et al., 2012). They can be distinguished from other birds by morphological features such as beaks with curved mandibles, zygodactyly (*i.e.* union of digits) with two opposing pairs of toes and a prehensile tongue (Forshaw, 2010). Plumage is green in most species except cockatoos, which lack this colour. Many psittacines are known to live in flocks with numerous members composed of breeding pairs and family groups (Evans, 2001). Some parrot species even express social play behaviour, which has been referred to as unique among birds (Diamond et al., 2006). The New Zealand kakapo (*Strigops habroptila*) is a notable exception because of its solitary lifestyle (Morris, 1977; Diamond et al., 2006).

Parrots have been kept in captivity for several purposes. Van Hoek and ten Cate (1998) identify two captive scenarios that apply for parrots: animals living as part of zoological collections and individuals kept as household pets. Each situation has different validating reasons for captivity: conservation and companionship.

Psittaciformes are classified as one of the most threatened bird groups according to The World Conservation Union's 2000-2004 Status Survey and Conservation Action Plan (2000). Data from Bennet and Owens (1997) describe them as one of eight bird families with significantly more threatened species. The biggest pressures for their survival are habitat destruction and direct exploitation (Beissinger and Bucher, 1992). For example, Spix's macaws (*Cyanopsitta Spixii*) are considered to be extinct in the wild and the species only survives thanks to *ex situ* captive breeding efforts (Reinschmidt et al., 2008; Tschudin et al., 2010; Hammer and Watson, 2012).

In the United States, an estimated 10.1 million parrots were kept as companion animals in 2002, making them the third most popular pet (Kalmar et al., 2010). Existing data on other countries show that in the Netherlands there are approximately 5.35 million pet psittacines (Roe, 1991). Previous records for the United Kingdom indicate a population of 5 million budgerigars (*Melopsittacus undulatus*) in private homes (Roe, 1991).

Universities and laboratories also house certain parrot species for cognitive studies since parrots have been described as "cognitively superior to other birds and in many cases even apes" (Emery, 2006). The literature is well represented by experiments examining African grey parrot (*Psittacus erithacus*) cognition and communication (Pepperberg, 1983, 1990, 1993). A review of all psittacine studies published in 2009 found a total of 483 individuals used in laboratory settings (Kalmar et al., 2010). The intelligence and longevity that characterise parrots increase concerns for their captivity (Kalmar et al., 2007).

## 2. Parrots in captivity: well-being as a problem and enrichment as a solution

### 2.1 Captivity-related problems

The “Five Freedoms” is a framework to assess well-being proposed by the UK’s Farm Animal Welfare Council. It states that animals should be free 1) from thirst, hunger and malnutrition; 2) from discomfort; 3) from pain, injury and disease; 4) to express normal behaviours and 5) from fear and distress. In this context, a well-being problem occurs when one or more of these principles are not satisfied. If this framework is applied to captive wildlife, the principles may be accomplished by the provision of appropriate husbandry practices and veterinary care. The last two “freedoms”, however, could appear more complicated to guarantee since environmental cues might influence the animals’ behaviour.

Restrictions to the expression of normal behaviours are often imposed by captive living conditions. One of the most recognised avian behaviours is flight. A study on a non-psittacine bird (Peng et al., 2013) assessed well-being impacts of constrained flight in captivity due to cage size and anatomical manipulation (*i.e.* wing clipping). Results showed that captive subjects maintained a preference to fly, evidenced by higher mean times spent in larger spaces and a decrease in size of the pectoral muscle of one subject. This study involves a small sample size and lacks statistical analyses, so general conclusions based on this design should be drawn with care. Brilot et al. (2009) analysed how abnormal behaviours (*e.g.* somersaulting, route tracing) developed after wild starlings (*Sturnus vulgaris*) were subjected to confinement, discussing how captivity promoted the development of stereotypical behaviour (*e.g.* somersaulting). Similar studies are still needed to determine the behavioural changes taking place in wild parrots following their confinement.

André (2007) provides a descriptive account of the behavioural repercussions commonly occurring in pet parrots. He outlines the most frequent problematic states as fearful, aggressive, excessive vocalisations, misdirected reproductive behaviour, stereotypical locomotion, feather-picking and over-

preening. The author suggests that the animals' raising environments, wild-caught, captive-born or human-raised, have a strong impact in the development of such conditions. Quantitative research has been focused on analysing fear (Meehan and Mench, 2002; Fox and Millam, 2004), stereotypies (Meehan et al., 2004; Garnet et al., 2006; de Andrade and de Azevedo, 2011; Poverino et al., 2015) and feather-picking (van Hoek and King, 1997; Meehan et al., 2003b). From a well-being perspective, it is clear that behaviours like feather plucking and excessive self-preening are detrimental for the individual. Fear, aggression and loud vocalisations tend to only be considered as negative by the owners' opinions. Foraging is another area of concern since captivity can limit the availability, frequency or distribution of food resources and the behavioural repertoire linked to this activity. In the wild, animals develop different strategies to obtain their food resources. Parrots employ several body parts (*e.g.* feet, beak and tongue) while eating in different manipulation methods according to food type (Zeigler, 1975). As reported by Rozek and Millam (2011), wild parrots usually spend around 40 to 75% of their awake time either searching for or accessing food, contrasting with 42 minutes out of a 12 hour day in captive orange-winged amazons (*Amazona amazonica*). This discrepancy does not necessarily imply a negative effect on well-being. However, captive activity budgets may allow for negative behaviours to occupy the animals' "free" time.

Social play is an uncommon behaviour in bird species but present in many parrots. Social play in kea (*Nestor notabilis*), an inquisitive parrot, appears congruent between wild and captive specimens (Diamond et al., 2006). This may suggest that captivity does not hinder the expression of this behaviour but these results could be species-specific.

## **2.2 Past and present of parrot enrichment efforts**

To subdue abnormal behaviours and discourage inactivity, husbandry practices for captive wildlife often include the provision of environmental enrichment to increase behavioural diversity. For example,

114 Edinburgh Zoo manages an avian enrichment program with the objective of promoting full behavioural  
115 repertoires and use of all senses (Field and Thomas, 2000).

116 Newberry (1995) defines enrichment as “an improvement in the biological functioning of captive  
117 animals resulting from modifications to their environment”. However, there is no consensus on the  
118 exact mechanisms or procedures to achieve such improvement or the specific effects that should be  
119 expected. There is a generalised conception that environmental enrichment should improve on animals’  
120 living conditions. Other definitions are often influenced by the type of captive environment and/or the  
121 species of interest.

122 Most of the initial research on enrichment was based in laboratories. Rodents were the “go-to” subjects  
123 to test the effects of differential environments. Bennet et al. (1969) studied brain effects of rats kept in  
124 impoverished conditions. Colonies of two or three individuals were compared to enriched groups of 10  
125 or 12 in larger cages with toys provided. Elsewhere, brain weight of mice was compared when animals  
126 were housed in either standard (*i.e.* small cages and food containers) or enriched (*i.e.* large cages and  
127 food containers and objects for climbing and exploring; Henderson, 1970) settings. A similar neurological  
128 assessment was performed by Diamond et al. (1972) with rats in a similar setup: enriched (*i.e.* larger  
129 cages, social interaction and a variety of toys) or impoverished (*i.e.* single animals with no visual or  
130 physical conspecific contact). These experiments, while involving invasive procedures, concluded that  
131 improved housing had a positive effect on well-being. There are marked differences between the  
132 methodologies of early experiments with more recent studies in different settings.

133 Animals living in farming systems have to satisfy the producers’ interest to maximise economic gain. In  
134 the past, intensive breeding in barren conditions was a common scene but consumers have had an  
135 impact in the husbandry of farmed animals. Europe experienced the ban of battery cages for laying  
136 hens, mostly as a result of the public demand for improved animal welfare (Jones, 2004). Following on



the interest to provide better environments, preference and behavioural studies have analysed the provision of enrichment. Changes in aggression and feather damage in hens when given string and bales of wood shavings (Hocking and Jones, 2006) and provision of improved environments to farmed mink (*Mustela vison*; access to swimming water in Vinke et al., 2005; double cages, resting places and toys in Hansen, 2007) are just some examples. Lately, there has been a shift in the type of enrichment efforts provided to farmed animals. Discrimination of visual or acoustic operant tasks is the basis of what the corresponding literature labels as “cognitive enrichment”. Manteuffel et al. (2009) provide a review of this type of enrichment in farms. Results show a preference for cognitive challenges (Langbein et al., 2009) and a positive effect on well-being evidenced by decreased aggression, heart rate and fear (Zebunke et al., 2013). It is necessary to keep in mind the desired effects on well-being still have to comply with the interests of the farming industry, favouring some behaviours over others (*e.g.* less fearful or aggressive animals may be easier to manage).

Zoos also provide enrichment opportunities as part of their husbandry routines to enhance the well-being of their collection. Studies have tested the use of mazes and puzzles with primates (Brent and Eichberg, 1991; Gilloux et al., 1992; Clark and Smith, 2013) and cetaceans (Clark et al., 2013). All of these experiments showed modifications in the behavioural repertoire of their subjects such as an increase in social play and tool use (Clark and Smith, 2013); reduced aggression, affiliation, inactiveness, and self-directed behaviours (Brent and Eichberg, 1991); increased food-oriented behaviours (Gilloux et al., 1992) and improved vigilance and time spent underwater (Clark et al., 2013).

The studies above refer to animals other than birds; Coulton et al. (1997) comment on how enrichment studies in undomesticated animals appear biased towards non-avian species. For parrots, published research focuses on one of two directions: analysing options to diversify foraging strategies or determining object preferences.

Using the engine Web of Science, a search covering the totality of published material was performed using the keywords “parrot” and “enrichment” under “topic”. From the 57 articles found, 23 described the provision of enrichment to parrots. These were categorised under one of five enrichment types (see Young, 2003): social if tests included conspecifics as the dependent variable; occupational if a modification on the birds’ behaviour occurred without the use of food as a reward; physical if the living environment was modified in terms of size, complexity or furnishings; sensory if sight, audition, tact or smell were targeted or nutritional if food type or delivery method were part of the experimental procedures. Studies in which two or more of the previous enrichment types were clearly identified in their procedures were included in an additional “mixed efforts” category.

### **2.2.1 Social enrichment**

To determine if conspecific companionship on young parrots had an effect on their behaviour, same-sex pairs were compared to single-housed individuals (Meehan et al., 2003a). Every three months, for a year, subjects were focally sampled and received a handler-response test. Twice a year, responses to novelty tests were recorded. Data showed significantly different activity budgets between single and paired animals, with isolated parrots being less active and having a smaller behavioural repertoire. Both groups experienced a decrease in locomotion and an increase in enrichment use. Responses to handlers only differed when the person was not familiar to the animals tested. Discussion on well-being is made in terms of the occurrence of abnormal behaviours. None of the subjects developed feather picking or self-injurious tendencies. However, single birds developed an increase in self-preening, activity which could precede feather plucking. Stereotypical behaviours (pacing, route tracing, sham chewing, bar biting, flipping and tongue rolling) were found to be non-existent in birds housed with a conspecific, suggesting a positive effect on well-being. However, some paired birds needed veterinary attention because of injuries, possibly caused by their companions.

183 In a different experiment (Fox and Millam, 2004), unrelated juveniles were assigned to one of three  
184 treatments: removal from nest for hand-rearing, remaining with parents and handled by humans or  
185 undisturbed. At 3-4 months old, parrots were taken to a separate room and kept in cages with a sibling  
186 or compatible companion. Weeks later, to determine if neophobic tendencies were altered by rearing  
187 conditions, novel-object tests were implemented and plumage condition was also measured. At one  
188 year of age, parrots were presented one novel object to reassess fear responses. Latency to feed in the  
189 presence of a novel object was significantly different between treatments, with hand-raised individuals  
190 scoring lower times. Chicks that were handled while still with their parents showed poorer feather  
191 condition; parental feather picking was not examined but remained a possibility. Interestingly, at 1 year  
192 of age, birds were shown a toy and all individuals displayed neophobic tendencies, suggesting a  
193 transient or plastic effect by the tested protocols. Raising environment was treated as the independent  
194 variable, including contact with conspecific and humans and, as a consequence, was assigned to the  
195 social enrichment category. It could be argued that it implemented mixed efforts since food delivery  
196 methods differed between hand-raised and parent-raised parrots and physical enrichment was given  
197 after relocating them.

198 Garner et al. (2006) performed an analysis of genetic, environmental and social factors in stereotypical  
199 behaviours and feather picking. Individuals in single cages were kept in one of three rooms: unenriched,  
200 enriched or with half of the birds enriched. Enrichment included physical and foraging options but no  
201 clear description of devices or setups were provided. Behaviour was recorded by means of video  
202 cameras and plumage was scored for damage. Stereotypies were found to be unrelated to sex, family,  
203 distance from the room's door, age, or neighbouring conspecifics' stereotypies. Abnormal behaviours  
204 were found to be negatively correlated to the number of neighbouring birds, hinting at the importance  
205 of social stimulation. Due to the main conclusions being based on neighbouring birds, this research is  
206 classified as social enrichment.

### 2.2.2 Occupational enrichment

Behavioural enrichment took place with the development of a program to train macaws for artificial examination procedures (Leblanc et al., 2011). The training regime involved two handlers positively reinforcing desired behaviours ranging from parrots positioning on a specific place to accepting touches, massages and introduction of a speculum into the cloaca for females. Individual behavioural differences were observed in the subjects. The male *Ara chloropterus* emitted more distress calls, never accepted massages, and was more vigilant. The female *A. chloropterus* was the only bird to accept rewards from the first session but showed an increase in stereotypical behaviours throughout training procedures. The male *Ara ambiguus* had the highest participation and presented a decrease in stereotypies through most of the experiment. The female *A. ambiguus*, as the male *A. chloropterus*, never showed stereotypies. Authors concluded that the training program was successful with birds that finished all stages and had the greatest well-being benefits in *A. ambiguus* based on the lack of abnormal behaviours. This study provides insight in the use of behavioural training as an enrichment protocol but to determine its effectiveness on a given species, a larger sample size should be studied.

### 2.2.3 Physical enrichment

Wild migration patterns and their effect on environment exploration were analysed in ten parrot species (Mettke-Hoffman, 2000). Birds were classified for statistical tests as either nomadic or resident; two species were treated as both nomadic and resident since their origin was uncertain and different subpopulations have different migratory patterns. Birds were given hanging novel objects (*e.g.* mop, rope, tiles) two days later. Behaviour was recorded with 1-minute point sampling if subjects approached the device within 30 cm. Latency to touch the objects, number of objects touched and exploration duration were determined. Resident parrots engaged in exploration activities more than nomads and this happened with shorter latencies. Analyses accounted for dominance, sex and habituation. For

exploration times, both groups investigated single objects for similar periods. Authors found a positive correlation between length of exploration and feather plucking. The scope of this research focused on explaining exploration based on migration but the provision of novel object tests can be considered a form of enrichment.

Kim et al (2009) tested colour, size and hardness preferences using a switch that recorded every interaction between the birds and the objects provided. Six experiments explored approach latencies to wooden cubes varying in the previous properties. Yellow, wooden objects were significantly preferred over all options but brown, result not found when testing rawhide. Wooden enrichment produced six times more interactions than rawhide, suggesting a preference for destructibility. The data collection mechanism was an innovative way to account for interactions but it failed to record their intensity.

Webb et al. (2010) utilised the same method to test rope preferences. Rope differing in certain parameters (length, diameter, colour and fray) was presented to each bird. By integrating sex into their analyses, researchers discovered that both males and females preferred wound over frayed rope. Females demonstrated a tendency to engage more with longer ropes and males preferred smaller diameters. Both sexes preferred red rope over green and yellow. These results indicate that sex could be an important factor to consider when designing an enrichment program.

#### **2.2.4 Nutritional enrichment**

Early studies on foraging preferences analysed if parrots preferred a variable or a constant supply of food (Coulton et al., 1997). By using a piece of wood with 50 holes, food rewards were hidden in one of two configurations: one item in every hole or five items every ten holes. Behavioural data were recorded during pre-enrichment, enrichment and post-enrichment periods. An additional training phase occurred between pre-enrichment and enrichment, with no data collected. All subjects emptied the devices within 24 hours with the exception of one species (*Ara rubrogenys*) who rarely used it. Data

indicated that birds utilised enclosure fixings independently of the treatment. Climbing and allopreening had their minimum levels during the baseline phase. Less than 5% of the time of each observed hour was spent on the constant or variable setups, with no significant difference. From a well-being perspective, it could be argued that the device had a positive effect since it increased the expression of locomotion and affiliation behaviours. The use of the apparatus appeared to be minimal; an approach modifying additional aspects of foraging, not only food distribution, could provide additional information (see Van Zeeland et al., 2013). An interesting observation is the evidence of contrafreeloading, since there was a perceived preference of using the enrichment devices and ignoring dishes but this was not formally studied.

Foraging enrichment was provided to parrots that were previously kept as pets (Lumeij and Hommers, 2008). Two pipe feeders were provided to the enriched group while the control group was fed with their regular bowl (not provided to enriched birds) and empty pipe feeders. After one month, the treatments were crossed-over. Behaviour and plumage condition were analysed by means of a video camera and a feather-scoring system. Foraging times with and without operational feeders differed significantly. Interestingly, the group who had the control setup after being enriched interacted with the pipes in play behaviours, suggesting play could be a behavioural need. Plumage quality improved in most birds during the first month, with three cases of no changes and one of decreased score. Authors state that pipe feeders could be an effective treatment strategy in clinical cases of feather picking. This assumption should be examined more rigorously, since there could be additional factors governing the manifestation of this behaviour, especially since parrots kept as pets have different husbandry routines.

Van Zeeland et al. (2013) evaluated eleven devices that targeted different foraging manipulations (*e.g.* multiple locations, scattered, hidden, puzzles and larger sizes). Initially, baseline data was obtained by videotaping interactions with the birds' regular feeding bowl. Foraging was considered to be the amount of time spent moving, manipulating, searching for and consuming food. Overall, all tried enrichments

increased foraging times, strongly influenced by the time spent interacting with the devices and eating. Habituation is sometimes a concern with environmental enrichment but after seven days of experience there was no evidence of reduced foraging patterns. Items aiming to increase food extraction times were described as the most effective. Devices from the extraction and processing categories observed the greatest amount of food consumption. One of the puzzles had the lowest foraging time. Inferring a negative effect on well-being by the reduction of foraging times can be problematic. Increasing foraging times may reduce the time available to express abnormal behaviours but it can also decrease maintenance, socialisation or other behaviours not considered detrimental.

### **2.2.5 Mixed enrichment**

Millam et al. (1995) were interested in analysing the factors that governed breeding and reproduction of parrots. Using a colony of wild-caught psittacines for captive breeding, authors manipulated the physical environment and social structure, hoping for an increase in egg laying. Birds were housed in groups for approximately six months and then re-grouped as breeding pairs. For the first year, fifteen pairs were presented with nest boxes. Seven of these pairs were treated as a control and the remaining birds were provided a variety of enrichments which included: pair separation, misting, fruit variety, covered nest holes to promote manipulations and larger nest boxes. For the following year, previously enriched birds were relocated and former controls were grouped as same-sex flocks and then re-paired. Protocols were repeated but now boxes were provided at the same time to control and enriched birds, which did not happen on the previous phase. Egg laying was positively affected by enrichment opportunities (controls from the first trial laid eggs when they were enriched in the second phase). However, some parents had trouble caring for the young in the second test; two control pairs cannibalised their young in the second phase. Parrots were acclimatised to captivity for several months but perhaps this was not enough to ensure optimal breeding patterns.

300 Van Hoek and King (1997) examined feather picking and provided enrichment to conures housed as  
301 pairs. Parrots were observed during four stages: pre-enrichment, enrichment 1 (encouraging food-  
302 related activity and toys), enrichment 2 (changing available perches) and enrichment 3 (providing both  
303 enrichment 1 and 2). For data analyses, birds were divided in two groups: low/non-existent and  
304 noticeable feather problems. This division may have a direct effect on the obtained results since feather  
305 picking occurred in both groups. Birds with visible plumage damage were significantly more stationary  
306 and performed more preening, allopreening and other intra-pair activities. The feather problems of all  
307 birds stabilised during the study but there were no signs of improvement in birds on the second group.  
308 Authors discussed that nutritional effects were not suspected since they provided a mineral block as  
309 enrichment which was never used and the birds were fed the same diet. It seems premature to conclude  
310 such remarks: perhaps the birds were neophobic towards the block and providing equal diets does not  
311 ensure equal consumption.

312 Fear and exploration of juveniles were investigated by providing enrichment to promote foraging and  
313 locomotor activities (Meehan and Mench, 2002). After two days of habituation in individual cages, birds  
314 were handled for taming purposes. Enriched birds were exposed to foraging (*e.g.* cloth bags, fruit cages,  
315 toy box and treat basket) and physical (*e.g.* springs, bridges, diamonds) devices. Behaviour in the  
316 presence of novel objects (*e.g.* small pine, toy chicken, etc.) and responses to familiar and unfamiliar  
317 handlers was analysed. Enrichment resulted in shorter latencies to approach novel objects, indicating  
318 decreased fearfulness rather than increased exploration. Overall, novelty latency, duration and bout of  
319 interactions, motivation for human interaction and fear of unfamiliar handlers were affected by  
320 enrichment protocols, shaping a general increase in exploration. In a following setup with the same  
321 enrichment protocols and sample (Meehan et al., 2003b), the effects of enrichment on feather picking  
322 were examined. With a feather-scoring system, enriched birds' plumage improved while unenriched  
323 amazons' condition worsened. A second phase, in which enrichment was provided to control birds, saw



an improvement on plumage. It was not possible to determine the success rate of individual devices or categories. A third study with these same parrots focused on the development of cage stereotypies (Meehan et al., 2004). Parrots that received enrichment spent significantly less of their active time performing stereotypies. Control birds (*i.e.* those not receiving enrichment) were enriched during a posterior phase and results showed a decrease from 13 to 3% of their active time stereotyping. The environmental modifications in this experiment were able to alter magnitude, rate and timing of time spent on abnormal behaviours but they were not sufficient to completely prevent development.

In another experiment (Luescher and Sheehan, 2005), the behavioural development of chicks was investigated by providing different rearing environments. At their third week of age, chicks were moved into plastic tubs and allocated into one of four treatments: enriched environment and supplementary daily handling (*i.e.* additional handling to that required for hand-feeding), enriched environment with no extra handling, restricted environment and extra handling or restricted environment with no extra handling. Enrichment conditions involved being housed with a conspecific, brightly-coloured tub sides and a set of 20 toys. Novel object tests were performed to collect data on initial reaction, latency to touch and duration of exploration. Conures also participated in a novel conspecific test, analysing if parrots approached each other or not during one minute. Environment exploration was assessed with an open-field test, determining the number of areas entered, seeds eaten, latency to take their first step, latency to shake their feathers and latency to pick up a seed. Emergence tests were carried in which birds were placed in a box divided in equal halves (one side bright and the other dark) with a raising door. Conures were placed in the dark area, the division was raised and the latencies of head and full body emergence were recorded. Latency to take a hand-held treat was also measured. A behavioural assessment of reactions to cages being opened, handler's hand introduced, handling and restraint was also carried out. Finally, a learning test where birds had to discriminate between three coloured containers, with one containing a reward was carried. The main conclusions of these setups

indicated that enrichment and handling resulted in a significant decrease of fear responses; exploration was also affected by these treatments. There is a clear experimental diversity which provides sufficient data for comparisons. It should be noted that for the learning tests birds were food deprived overnight. This raises concerns regarding animal well-being (ethics of food withdrawal) and scientific validity (the need to satiate hunger may dominate any other motivation).

Fox and Millam (2007) measured neophobic responses under high and low novelty treatments in a cross-over design. Enrichment involved the provision of a variety of foraging devices and wooden and plastic toys. Birds in the high enrichment category had their enrichments changed several times per week, ensuring no individual was exposed to a given device more than once per week; parrots receiving low novelty did not have their enrichments replaced. Neophobia was measured by latency to approach a food reward in the presence of a novel object. Shorter latencies were observed in the high novelty group. Birds in this category that were described as moderately fearful experienced a greater decrease in neophobic levels. However, this treatment was not as effective in the most fearful birds. Rearing (*e.g.* parent or hand-raised) did not have a significant effect by itself but the interaction of rearing with treatment, object and between these three factors proved significant. It was concluded that a frequent rotation of enrichment appears more effective in shaping exploration than provision itself.

An analysis of foraging times by manipulating food properties and presenting wooden cubes was performed by Rozek et al. (2010). By using a computer-monitored data collection system, behaviour was recorded during four experimental setups. In the first experiment researchers validated their methodology by comparing data with videotaped behaviours. Next, oversized pellets were introduced into the birds' diet; regular pellets were gradually removed after the amazons were judged proficient in feeding on the novel regime. Feeding behaviour was determined based on displacement. Birds were then offered one of two diets: either regular and oversized pellets or only regular. Finally, two wooden cubes were located on the cages' walls to determine pellet removal. Oversized pellets had several

372 effects on behaviour: they increased both time between feeder visits and manipulations of pellets with  
373 foot and beak when compared to regular feed. Preference for the novel diet was evidenced by removing  
374 more regular diet when oversized was absent. The presence of wooden cubes did not affect food  
375 consumption. Reinforcing oversized pellet preference, cubes had a higher level of destruction when  
376 these pellets were absent. Results from pellet and cube manipulation indicate an appetite for  
377 manipulation. A follow-up experiment (Rozek and Millam, 2011) explored preferences for regular pellets  
378 compared to two larger sizes and responses to wooden cubes. Similarly, four experimental stages  
379 investigated larger pellet preference in the presence of regular food but now diets were provided in a  
380 feeder with weights on the access lid. Preference between the two large pellets in the absence of  
381 regular food, motivation to destroy a wooden cube in the presence of different pellet sizes and a  
382 verification test to ensure birds were working for the pellets themselves and not a secondary  
383 reinforcement (*i.e.* lifting feeders' doors) were investigated. In the first experiment, parrots removed  
384 more oversized than larger pellets, analogous to the observations of experiment two. Pellet size had an  
385 effect on the maximum paid price (*i.e.* weight lifted) to access cubes. As with previous research (Rozek  
386 et al., 2010) cubes were preferred when only regular pellets were available. Interestingly, observations  
387 from their fourth setup did not evidence contrafreeloading.

388 De Andrade and de Azevedo (2011) provided a variety of enrichment opportunities (*e.g.* pinecones with  
389 fruits, branches, cardboard boxes, leather pendants) to reduce abnormal behaviours. Items were chosen  
390 to enhance foraging, socialisation and exploration. By means of an ethogram, behavioural data were  
391 collected during three stages: pre-enrichment, enrichment and post-enrichment. Stereotypies were  
392 found to decrease between stages but without significant differences. Data clearly showed changes in  
393 foraging patterns during experimental phases. Exploration was explained by changes in standing  
394 behaviours but these rather describe different locomotion patterns. Since enrichment interaction was  
395 grouped with "other" behaviours, further analyses to specifically assess enrichment exploration should

take place. Authors judged the effects of their procedures as positive for the animals' well-being but the measures were not adequate or sufficient enough to eliminate stereotypies.

Two more experiments analysing stereotypical were performed by Polverino et al. (2015). In the first setup, parrots were treated to one of three conditions: housed as pairs in small cages, pairs in large cages or social housing in large cages. For the second, social enrichment was provided to birds previously in the paired-large cage treatment. Oral, locomotor and object-based stereotypies were compared between treatments along with normal behaviours. Housing conditions were determined to have an effect on all abnormal behaviours, including frequency and duration. Self-grooming also occurred more often and for longer periods when imposing social and spatial limits. Sex was also found to have an effect between housing conditions. When pairs were rearranged for the second experiment, oral and object-directed stereotypies did not differ significantly. On the other hand, abnormal locomotion behaviours were significantly reduced when pairs formerly housed in large cages were socially enriched. Authors conclude by mentioning how budgerigars may be better adapted to limitations in their environment since, in contrast to other psittacine species, they have been exposed to captivity for a longer time.

Cussen and Mench (2015) studied the link between enrichment, behaviour and personality of Amazons. Parrots were exposed to enrichment in the form of objects, feeders and human interaction. Results show how a change towards unenriched conditions had an impact in well-being as showed by a decrease in feather condition and an increase in stereotypy duration. However, results varied in the individual level and this was explained in terms of personality: "more extraverted parrots had smaller increases in the proportion of active time they spent engaged in locomotor stereotypy".

An analysis of feather plucking behaviour and its link with enrichment and pharmacology was performed by Telles et al. (2015) with juvenile parakeets. One group was provided with physical, foraging and

sensory enrichment while a second group was treated with haloperidol. After obtaining baseline and experimental behavioural data, it was observed that the parakeets in the enriched group had seen a greater improvement in feather condition compared to the haloperidol group. Enriched birds also performed more species-specific behaviours and were more active during observation periods.

### **3. The future of psittacine enrichment**

Literature on psittacine enrichment is dominated by studies targeting foraging behaviours as well as object preference. Table 1 summarises relevant parameters of the reviewed experiments and shows how orange-winged Amazons are the most represented parrots in enrichment studies with 13 out of 23 studies. Variables such as sample size and experiment duration also present high variability among experiments, which complicates comparisons of results. Sensory and occupational enrichment are areas of opportunity for future research since only one study was found to discuss purely occupational procedures and none were found for sensory measures.

INSERT TABLE 1 HERE

Table 1. Summary of variables and conclusions of enrichment studies on psittacine birds.

Parrot intelligence, suggested to be similar to that of great apes and marine mammals (Kalmar et al., 2007), has triggered an increase in cognitive research with these species, especially with African grey parrots and kea. Special devices and training procedures have been provided and while the aim was not to evaluate the apparatuses as enrichment, they could be considered as such. Cognitive studies with kea have analysed tool use (Auersperg et al., 2010, 2011a, 2011b), object manipulation (Werdenich and Huber, 2006; Liedtke et al., 2011; Gajdon et al., 2013), cooperation (Tebbich et al., 1996) and lock-opening (Miyata et al., 2011). African grey parrots have received great attention by their demonstrated cognitive and communicative abilities (see Pepperberg, 1999 for an in-depth overview). Pepperberg's tests often involve learning sessions where subjects are asked to describe or identify objects. Her

442 research contrasts with other studies since no food rewards are utilised to reinforce participation,  
443 evidencing a different motivation from hunger and allowing the possibility of truly labelling these  
444 experiments as occupational enrichment.

445 Research has clearly evolved from early laboratory setups including barren environments to providing  
446 cognitive challenges as enrichment both in farms and zoos. Bauck (1988) discusses how psychology labs  
447 pioneered the use of machines for feeding purposes, considering them enrichment precursors and how  
448 toys are now common enrichment opportunities. Maybe returning to the earlier psychological setups,  
449 with appropriate modifications, could be of benefit for animal well-being. Clark (2011) makes an  
450 interesting suggestion for zoological institutions in regards to enclosure design. She proposes a “high-  
451 investment approach to cognitive enrichment” in which animals would have access to separate areas  
452 with different tasks. She discusses the difficulties of such method, mostly related to financial and  
453 maintenance costs. However, the use of technology is advised as a possible solution, concept shared by  
454 Pepperberg (2004).

455 The future of not only psittacine but of all captive wildlife enrichment should be directed towards  
456 appropriate tasks where physical and mental health is promoted.

457 The enrichment of parrots living as human companions could be more difficult to study and analyse due  
458 to the different factors associated to the lack of homogenous environments. Previous work with pet  
459 parrots (Lantermann, 1997) surveyed 258 parrot owners and discovered that a large number of birds  
460 were housed under favourable settings. Educating owners about the proper ways in which to keep  
461 parrots is an easy solution to this problem. For example, ©Avian Studios ([www.avianstudios.com](http://www.avianstudios.com)) has  
462 developed a series of educational videos directed towards bird owners in which housing, nutrition and  
463 diseases are discussed. A separate volume explains environmental enrichment based on natural foraging  
464 instincts.

#### 4. Conclusion

Providing animals something to do will, evidently, have an effect on their activity budgets. Avian behaviours are generally divided into foraging, socialisation, grooming and resting (Echols, 2010). Echols proposes that when one of these categories is reduced due to captivity the others increase, leading to behavioural abnormalities such as excessive or detrimental preening. This theory, however, does not really explain the appearance of other abnormal behaviours such as stereotypies since “locomotion” is missing from the described behaviour groups. Thus, these categories might fail to describe the full behavioural repertoire of parrots. Enrichment studies discussed earlier show the possibility of adding “play” as another behavioural category, since many studies based on the provision of physical or mixed enrichment include objects such as toys. The behaviour of New Zealand parrots (Strigopoidea) in the wild does include episodes of social play with interspecific variation in composition, duration, intensity, structure and reciprocity (Diamond et al., 2006), supporting the inclusion of play as a behaviour category. The purpose of enrichment should be to go beyond modifying activity budgets.

Given parrots’ conservation status, cognition and presence in laboratories and households, they should receive appropriate living environments. Their enrichment should be of biological significance and include appropriate challenges (Kalmar et al., 2010) to promote their well-being. This article has detailed the research directions that studies in parrot enrichment have taken. Most data show behavioural effects but modifications to activity budgets may not be the desired consequence. For example, the scope of some studies looks into reducing neophobia in parrots (see Table 1) but one should ask if this behaviour is of biological significance for the birds or if neophobia is an innate trait.

Because of farmers’ interests, better control of their subjects and the influence of public opinion, studies in farm settings have examined the link between enrichment and well-being with more indicators (*e.g.* physiology, emotional states) than zoos. Multi-indicator welfare analyses should also be carried out in

zoological collections. Zoo research shows that enrichment does work: when analysing abnormal behaviours, stereotypies decrease in frequency (Swaigood and Shepherdson, 2006) but they do not disappear completely.

Enrichment is not only to be used for animals permanently in captivity. Besides the mentioned effects on parrot behaviour, enrichment can have added benefits for their conservation (Millam, 1995; Watters and Meehan, 2007; Reading et al, 2013). Animals in short-term captivity for reintroduction purposes can also benefit from enrichment by promoting behaviours relevant for their survival and to avoid distress.

#### **Acknowledgments**

The author would like to thank Mike Mendl for his constructive feedback on an earlier version of this manuscript. This article was written while being funded by Consejo Nacional de Ciencia y Tecnología (CONACYT, México) with grant number 400265.

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<b>Species and sample size (number of parrots)</b>	<i>Amazona Amazonica</i> (21)	<i>A. Amazonica</i> (19)	<i>A. Amazonica</i> (64)	<i>Ara ambiguus</i> (2) and <i>Ara chloropterus</i> (2)	<i>Trichoglossus ornatus</i> (14), <i>Charmosyna josefinae</i> (10), <i>Charmosyna pulchella pulchella</i> (12), <i>Psephotus dissimilis</i> (14), <i>Trichoglossus haematodus moluccans</i> (12), <i>Psephotus varius</i> (14), <i>Neopsittacus pullicauda</i> (14), <i>Charmosyna papou goliathina</i> (14), <i>Northiella haematogaster</i> (14), <i>Psephotus haematonotus</i> (14)	<i>A. amazonica</i> (8 – 10)	<i>A. amazonica</i> (12)	<i>Ara rubrogenys</i> (4), <i>Rhynchopsitta pachyrhyncha</i> 2), <i>A. chloropterus</i> (2) and <i>Lorius garrulus</i> (2)
<b>Study duration</b>	12 months	12 months	NA	15 weeks	2 days	>13 days	57 days	102 hours
<b>Enrichment provided</b>	Conspecific companionship	Different rearing environments: parent-reared, parent-reared with human interaction or human-reared	Foraging and physical enrichment (not described), neighbouring conspecifics	Behavioural training for artificial insemination procedures	Novel objects: rope, cotton mop and three small blue plastic tiles	Wooden and rawhide cubes of different colours	Rope of different colours and sizes	Length of wood with two variations in food distribution.
<b>Well-being measure</b>	Stereotypy development, feather plucking, fearfulness and aggression	Latency to feed and fearfulness	Stereotypies and feather picking	Behavioural activity, stereotypies	Latency to touch novel object, number of objects touched and duration of exploration	Measured preferences for enrichment characteristics	Measured preferences for enrichment characteristics	Measured preference on enrichment's food supply
<b>Well-being conclusion</b>	Pair housing results in: more active and diverse behaviours, hindered stereotypy development, modifications to fear responses	Hand-reared birds less neophobic until 6 months of age. At 1 year of age, all groups showed similar levels of neophobia	Parrots with more neighbours showed less stereotypy, could not assess enrichment as a variable due to study design, proximity to a door associated with feather picking	Training did not result in stress or affected reproductive behaviours of both <i>A. ambiguus</i> . Female <i>A. chloropterus</i> stressed, probably due to training and/or external factors. Male <i>A. chloropterus</i> did not complete training.	Resident species showed earlier exploration; exploration positively correlated with feather-plucking	Not explicitly; suggest further studies examining the biological basis of preferences to improve welfare	Not explicitly; results could serve as guidelines for enrichment device development; suggest that devices' properties may trigger different motivation behaviours	Suggest increasing foraging opportunities successful as enrichment; induced more appropriate species-specific behaviours
<b>Reference</b>	Meehan et al., 2003a	Fox and Millam, 2004	Garner et al., 2006	Leblanc et al., 2011	Mettke-Hoffman, 2007	Kim et al., 2009	Webb et al., 2010	Coulton et al., 1997

<b>Species and sample size (number of parrots)</b>	<i>Psittacus erithacus</i> (18)	<i>P. erithacus</i> (12)	<i>A. amazonica</i> (30)	<i>Pyrrhura perlata</i> (10)	<i>A. amazonica</i> (16)	<i>A. amazonica</i> (16)	<i>A. amazonica</i> (16)	<i>Nandayus nenday</i> (48 test subjects and 27 as social enrichment)
<b>Study duration</b>	2 months	>12 weeks	2 years	24 weeks	1 year	48 weeks	48 weeks	6 weeks
<b>Enrichment provided</b>	Pipe feeders	Foraging enrichment	Pair separation, misting, fruits, nest hole restriction and larger next boxes	Foraging enrichment, addition of perches	Increased cage physical complexity and provided foraging enrichment	Increased cage complexity and provided foraging enrichment	Increased cage complexity and provided foraging enrichment	Physical enrichment, handling by humans, social enrichment
<b>Well-being measure</b>	Feather picking	Studied effects on foraging activity	Egg laying	Feather picking	Responses to novelty and human handlers	Feather picking	Development of stereotypic behaviours	Novel object, novel conspecific, open field, emergence, latency to feed, learning tests and behavioural assessment
<b>Well-being conclusion</b>	Pipe feeder increased foraging time and feather condition	Not explicitly; foraging enrichment can increase foraging times	Parrots' sexual activity stimulated by enrichment protocols;	Stabilisation of plumage problems during study, natural and edible materials more successful	Enrichment reduced fear and motivation for environmental interaction	Decreased feather picking	Stereotypies nearly prevented through their enrichment protocol	Protocols reduced fear levels and increased exploration in some tests
<b>Reference</b>	Lumeij and Hommers, 2008	Van Zeeland et al., 2013	Millam et al., 1994	Van Hoek and King, 1998	Meehan and Mench, 2002	Meehan et al., 2003b	Meehan et al., 2004	Luescher and Sheehan, 2005

<b>Species and sample size (number of parrots)</b>	<i>A. amazonica</i> (34)	<i>A. amazonica</i> (6-12)	<i>A. amazonica</i> (10)	<i>Aratinga leucophthalma</i> (10)	<i>Melopsittacus undulatus</i> (36)	<i>A. amazonica</i> (13)	<i>Aratinga leucophthalma</i> (12)
<b>Study duration</b>	25 weeks	>4 weeks	7 months	7 months	8 months	40 weeks	3 weeks
<b>Enrichment provided</b>	Foraging devices and toys	Foraging enrichment	Foraging enrichment	Foraging enrichment	Physical and social enrichment	Variety of physical foraging and social enrichment by handlers	Several items for sensory, foraging and physical enrichment
<b>Well-being measure</b>	Novel object test	Behavioural analysis, pellet preference	Motivation for pellet types, destructible cubes, contrafreeloading, podomandibulation	Behavioural analysis	Behavioural analysis	Development of abnormal behaviours	Feather picking
<b>Well-being conclusion</b>	Rotation of devices more effective than enrichment itself to reduce fear	Oversized pellets made foraging times similar to wild activity, parrot appetites motivated by food form	Parrots exhibit motivation to perform naturalistic behaviour; link with welfare not clear	Reduced abnormal behaviours non-significantly	Stereotypies reduced when birds allowed to interact with multiple social partners	Deprivation of enrichment decreased feather condition and increased time spent stereotyping	Environmental enrichment more effective in treating feather picking when compared to drug treatment
<b>Reference</b>	Fox and Millam, 2007	Rozek et al., 2010	Rozek and Millam, 2011	de Andrade and de Azevedo, 2011	Polverino et al., 2015	Cussen and Mench, 2015	Telles et al., 2015

# Environmental enrichment for parrot species: are we squawking up the wrong tree?

Rogelio Rodríguez-López<sup>ab</sup>

<sup>a</sup>University of Bristol. School of Veterinary Sciences. Langford House, Langford, Bristol, UK BS40 5DU.

<sup>b</sup>Bristol Zoo Gardens. Clifton, Bristol, UK, BS8 3HA.

+44 7429082763 [rogelio.rodriquez@bristol.ac.uk](mailto:rogelio.rodriquez@bristol.ac.uk)

## Abstract

Parrots are kept in zoos, homes and laboratories for conservation, companionship and research purposes. The intelligence, longevity and behaviour of parrots raise concerns for keeping them in these environments. Captive settings may limit the expression of normal behaviours and, as a consequence, abnormal behaviours may develop. Husbandry practices often provide animals with enrichment opportunities to prevent negative effects on their well-being. The purpose of this review is to examine the existing literature on parrot enrichment to identify which efforts are successful with these species and detect areas where more work is needed. A total of 23 articles were found to provide enrichment to parrots. Based on these, research has centred on options to diversify foraging strategies and determine object preferences. Studies analysing well-being focus on abnormal behaviour in the form of stereotypies and feather picking. Variables such as sample size and protocol duration present variable ranges across experiments. There is an under-representation of parrot enrichment studies in zoos. The most documented types of enrichment involve foraging and physical modifications while enrichment based on sensorial stimuli is non-existent. Other studies focusing on cognitive or technical capacities of parrots were not included as enrichment efforts. However, they have the potential to be considered as such if well-being is integrated into their analyses. Parrot enrichment does result in behavioural changes; exploration is already well documented. Further work should be directed towards exploring additional well-being indicators, especially in zoo environments. Environmental enrichment is not an easy concept to define since it is highly dependent on species-specific variables. Diet and sociality are varying factors across parrot species that require attention when deciding what enrichment they may benefit of. In addition to being biologically relevant,

enrichment should include opportunities to solve challenges and exert control on the environment. Environmental enrichment may also be of benefit to wildlife conservation.

## **Keywords**

Parrots, Environmental enrichment, Well-being

## **1. Introduction**

Psittaciformes, members of the aves class commonly known as parrots, are comprised by three groups: New Zealand parrots (Strigopoidea), cockatoos (Cacatuoidea) and all other parrots (Psittacoidea) (Joseph et al., 2012). They can be distinguished from other birds by morphological features such as beaks with curved mandibles, zygodactyly (two opposing pairs of toes) and a prehensile tongue (Forshaw, 2010). Plumage is green in most species, except cockatoos. Many psittacines are known to live in flocks of numerous members, composed of breeding pairs and family groups (Evans, 2001), but there are exceptions such as the New Zealand kakapo (*Strigops habroptilus*) (Diamond et al., 2006). Play behaviour is also characteristic of psittacine species. Parrots exhibit all three forms of play: solitary, object and social. (Kaplan, 2015 page 79). Several avian orders have been reported to exhibit locomotive or object play (Diamond and Bond, 2003) but only Psittaciformes, Passeriformes (passerines) and Bucerotiformes (hornbills) express social play (Diamond and Bond, 2003; Diamond et al., 2006). Social play is more widespread in parrots, with evidence found in 13 species compared to 10 species of corvids and two species of hornbills (Kaplan, 2015 page 79).

Parrots have been kept in captivity for several purposes. Van Hoek and ten Cate (1998) identify two captive scenarios: zoological collections and household pets. Each situation has different validating reasons for captivity: conservation and companionship. Psittaciformes are classified as one of the most threatened bird groups according to The World Conservation Union's 2000-2004 Status Survey and Conservation Action Plan (2000). Bennet and Owens (1997) describe them as one of eight bird families with significantly higher numbers of threatened species. The biggest threats to their survival are habitat destruction and direct exploitation (Beissinger and Bucher, 1992). Spix's macaws (*Cyanopsitta Spixii*) are considered to be extinct in the wild, with the species only surviving thanks to *ex situ* captive breeding efforts (Reinschmidt et al., 2008; Tschudin et al., 2010; Hammer and Watson, 2012). In the United States, an estimated 10.1 million parrots were kept as companion animals in

2002, making them the third most popular pet (Kalmar et al., 2010). Existing data on other countries show that in the Netherlands there are approximately 5.35 million pet psittacines (Roe, 1991). Previous records for the United Kingdom indicate a population of 5 million budgerigars (*Melopsittacus undulatus*) in private homes (Roe, 1991).

Universities and laboratories also house certain parrot species for research purposes as they have been described as “cognitively superior to other birds and in many cases even apes” (Emery, 2006). The literature is well represented by experiments examining African grey parrot (*Psittacus erithacus*) cognition and communication (Pepperberg, 1983, 1990, 1993). A review of all psittacine studies published in 2009 found a total of 483 individuals in laboratory settings (Kalmar et al., 2010). The intelligence and longevity that characterise parrots raise concerns for keeping them in captivity (Kalmar et al., 2007).

## **2. Parrots in captivity: well-being as a problem and enrichment as a solution**

### **2.1 Captivity-related problems**

The “Five Freedoms” is a framework to assess well-being proposed by the UK’s Farm Animal Welfare Council. It states that animals should be free 1) from thirst, hunger and malnutrition; 2) from discomfort; 3) from pain, injury and disease; 4) to express normal behaviours; and 5) from fear and distress. A welfare problem occurs when one or more of these principles are not satisfied. In the setting of captive wildlife, the Five Freedoms may be accomplished by appropriate husbandry and veterinary practices (*i.e.* provision of food and water, an adequate physical living environment and medical care). However, the last two freedoms could appear more complicated to achieve.

Restrictions to the expression of normal behaviours are often imposed by captive living conditions. One of the most recognised avian behaviours is flight. A study on a non-psittacine bird (Peng et al., 2013) assessed well-being impacts of constrained flight in captivity due to cage size and anatomical manipulation (*i.e.* wing clipping). Results showed that captive subjects maintained a preference to fly, evidenced by higher mean times spent in larger spaces and a decrease in size of the pectoral muscle of one subject. This study involves a small sample size and lacks statistical analysis, so general conclusions based on this design should be drawn with care.



André (2007) provides a descriptive account of the behavioural repercussions commonly occurring in pet parrots. He outlines the most frequent problems as fear, aggression, excessive vocalisations, misdirected reproductive behaviour, stereotypical locomotion, feather-picking and over-preening. The author suggests that the animals' rearing environment (wild-caught, captive-born, parent or human-raised) has a strong impact on the development of such conditions. Quantitative research has been focused on analysing fear (Meehan and Mench, 2002; Fox and Millam, 2004), stereotypies (Meehan et al., 2004; Garnet et al., 2006; de Andrade and de Azevedo, 2011; Polverino et al., 2015) and feather-picking (van Hoek and King, 1997; Meehan et al., 2003b). From a welfare perspective, it is clear that behaviours such as feather plucking and excessive self-preening are detrimental for the individual whereas fear, aggression and loud vocalisations tend to be considered negative because owners prefer calm and sociable pets.

Foraging behaviour is a concern as captivity can limit the availability, frequency or distribution of food resources and the behavioural repertoire linked to this activity. In the wild, animals develop different strategies to obtain their food resources. Parrots employ several body parts (e.g. feet, beak and tongue) while eating; manipulation methods vary according to food type (Zeigler, 1975). As reported by Rozek and Millam (2011), wild parrots spend around 40% to 75% of their awake time searching for or accessing food, contrasting with 42 minutes out of a 12-hour day in captive orange-winged amazons (*Amazona amazonica*). This discrepancy does not necessarily imply a negative effect on well-being. However, captive activity budgets may allow for abnormal behaviours to occupy the animals' "free" time.

The repercussions of captivity in psittacine play behaviour have not been extensively researched. However, social play in kea (*Nestor notabilis*), an inquisitive parrot, appears consistent between wild and captive specimens (Diamond et al., 2006). This may suggest that captivity does not hinder the expression of this behaviour but these results may be species-specific.

Brilot et al. (2009) analysed how abnormal behaviours (e.g. somersaulting and route tracing) developed after wild starlings (*Sturnus vulgaris*) were subjected to confinement, discussing how captivity promoted the development of stereotypical behaviour. Similar studies are still needed to determine the behavioural changes taking place in wild parrots following their confinement.

## **2.2 Past and present of parrot enrichment efforts**

To subdue abnormal behaviours, discourage inactivity and increase behavioural diversity, husbandry practices for parrots often include the provision of environmental enrichment. For example, Edinburgh Zoo manages an avian enrichment program with the objective of promoting full behavioural repertoires and use of all senses (Field and Thomas, 2000).

Newberry (1995) defines enrichment as “an improvement in the biological functioning of captive animals resulting from modifications to their environment”. However, there is no consensus on the exact mechanisms or procedures to achieve such improvement or the specific effects that should be expected. There is a general notion that environmental enrichment should improve living conditions. Other definitions are often influenced by the type of captive environment and/or the species of interest.

Early research on enrichment was carried out in laboratories. Rodents were the “go-to” subjects to test the effects of differential environments. Bennet et al. (1969) studied brain effects of rats kept in impoverished conditions. Colonies of two or three individuals were compared against enriched groups of 10 or 12 individuals in larger cages with toys. Henderson (1970) compared brain weight of mice when animals were housed in either standard (*i.e.* small cages and food containers) or enriched (*i.e.* large cages and food containers and objects for climbing and exploring) settings. A similar neurological assessment on rats was performed by Diamond et al. (1972) using enriched (*i.e.* larger cages, social interaction and a variety of toys) or impoverished (*i.e.* single animals with no visual or physical conspecific contact) environments. These experiments, while involving invasive procedures, concluded that improved housing had a positive effect on well-being.

Animals living in farms may be managed differently because they have to satisfy producers’ interest and maximise economic gain. In the past, intensive breeding in barren conditions was a common scene but consumers have had an impact on the husbandry of farmed animals. Europe experienced the ban of battery cages for laying hens mostly as a result of public demand for improved animal welfare (Jones, 2004). Following on the interest to provide better environments, preference and behavioural studies have analysed enrichment provision in farms. Changes in aggression and feather damage in hens when given string and bales of wood shavings (Hocking and Jones, 2006) and improved environments for farmed mink (*Mustela vison*; access to swimming water in Vinke et al., 2005; double cages, resting places and toys in Hansen, 2007) are just some examples. Lately, there

has been a shift in the type of enrichment efforts provided to farmed animals. Discrimination of visual or acoustic operant tasks is the basis of what the literature labels as “cognitive enrichment”. Manteuffel et al. (2009) provide a review of this type of enrichment in farms. Results show a preference for cognitive challenges (Langbein et al., 2009) and a positive effect on well-being in terms of decreased aggression, heart rate and fear (Zebunke et al., 2013). It is necessary to keep in mind the desired effects on well-being still have to comply with the interests of the farming industry, favouring some behaviours over others (e.g. less fearful or aggressive animals may be easier to manage).

Zoos also provide enrichment opportunities as part of their husbandry routines to enhance the well-being of their collection. Studies have tested the use of mazes and puzzles with primates (Brent and Eichberg, 1991; Gilloux et al., 1992; Clark and Smith, 2013) and cetaceans (Clark et al., 2013). These experiments showed modifications in the behavioural repertoire of the subjects such as: an increase in social play and tool use (Clark and Smith, 2013); reduced aggression, affiliation, inactivity, and self-directed behaviours (Brent and Eichberg, 1991); increased food-oriented behaviours (Gilloux et al., 1992); and improved vigilance and time spent underwater (Clark et al., 2013). These studies refer to animals other than parrots, showing a lack of attention to these species. Coulton et al. (1997) commented on how enrichment studies in undomesticated animals appear biased towards non-avian species. In labs, rodents are among the most studied animals. A review by Fox et al. (2006) on the effects of enrichment on stress includes 108 references: 83 refer to studies on rodents, four on domestic animals and nine on wild species in captivity.

The purpose of this article is to review the existing literature on parrot enrichment to identify and analyse their methods and conclusions as well as determine areas where more research is required. Using the engine Web of Science, a search covering the totality of published material was performed using the keywords “parrot” and “enrichment”. From the 57 articles found, 23 were relevant to the provision of environmental enrichment to parrots. These were categorised under one of five enrichment types (see Young, 2003): 1) Social if tests included conspecifics as the dependent variable or explicit interaction with humans; 2) Occupational if a modification on the birds’ behaviour occurred without the use of food as a reward; 3) Physical if the living environment was modified in terms of size, complexity or furnishings; 4) Sensory if vision, audition, touch or olfaction were targeted; and 5) Nutritional if food type or its delivery method were part of the experimental procedures. Studies

in which two or more of the previous enrichment types were identified were included in an additional “mixed” category.

### **2.2.1 Occupational enrichment**

Only one study was considered as occupational enrichment (Leblanc et al., 2011). Here, a training regime for two male-female pairs of captive macaws (*Ara chloropterus* and *A. ambiguus*) was analysed. Two handlers positively reinforced desired behaviours relating to artificial insemination procedures. The male *A. chloropterus* emitted more distress calls, never accepted massages and was more vigilant. The female showed an increase in stereotypical behaviours. The male *A. ambiguus* had the highest participation and presented a decrease in stereotypies throughout most of the experiment. The female *A. ambiguus* and the male *A. chloropterus* did not show stereotypies and this was considered as a sign of enhanced well-being.

### **2.2.2 Social enrichment**

Three articles were found to investigate social variables. Meehan et al. (2003a) explored the effects of conspecific companionship on behaviour. Fox and Millam (2004) assessed the effects of rearing environment (*i.e.* parent-reared, human-reared, or parent-reared with limited human contact) on behaviour and feather condition. Garner et al. (2006) analysed the effect of neighbouring parrots on abnormal behaviours. Data from the first study showed that parrots housed with a conspecific were more active, had a larger behavioural repertoire and did not exhibit stereotypical behaviours. Hand-raised subjects from the second study showed lower latencies to feed in the presence of novel objects but neophobic responses returned to baseline levels after one year. Garner et al. (2006) found that stereotypical behaviour was negatively correlated with the number of neighbours. The three studies assessed plumage, finding varying results. Meehan and colleagues (2003a) found that socially enriched birds (*i.e.* with a companion) did not engage in feather picking or self-injurious behaviour. Fox and Millam (2004) discovered that parrots left with their parents and exposed to limited human contact presented poorer feather quality. Garner et al. (2006) did not find a correlation between feather score and number of neighbours. Fox and Millam’s (2004) work involved different feeding strategies for the subjects depending on their rearing environment and provided physical objects upon juvenile relocation which could confound conclusions based solely on the social aspect. The Amazons

Garner et al. (2006) studied in terms of neighbours and abnormal behaviours were a subset of a bigger pool. Birds in two other rooms received physical and foraging enrichment.

### **2.2.3 Physical enrichment**

Three research experiments provided parrots with physical objects to analyse different variables. Ten species were given hanging novel objects to inspect the relationship between wild migration patterns and environment exploration (Mettke-Hoffman, 2000). Nomad species were found to engage in less exploration, with longer latencies to approach objects when compared to residents. The author also found a positive correlation between exploration duration and feather plucking behaviour.

The other two studies (Kim et al., 2009; Webb et al., 2010) utilised a novel technique to determine amazon parrots' preferences. Kim and colleagues tested for cube colour, size and hardness while Webb et al. looked into rope length, thickness and condition. Preferences were measured by attaching the objects to a switch that recorded every physical interaction. Wooden cubes produced six times more interactions than rawhide and wound rope was preferred over frayed rope. These results indicate that parrots favour elements that they can destroy. Yellow cubes were preferred over all colour options but brown, although this result was not found with rawhide. Females engaged more with longer ropes and males preferred smaller diameters. Both sexes preferred red rope over green and yellow. The data collection mechanism was an innovative way to account for interactions but it failed to record their intensity.

### **2.2.4 Nutritional enrichment**

Foraging enrichment was identified in five sources by methods analysing food dispensing devices or manipulating food size. Coulton and colleagues (1997) hid food items in wooden boards in two different setups: constant, with one reward per hole, and variable, with five rewards every ten holes. Results showed that time spent in enclosure fixtures, climbing and allopreening had minimum levels during the baseline phase but only the latter was attributed to the foraging apparatuses. One of the studied species, *Ara rubrogeny*, rarely used the wooden boards. An experiment with two pipe feeders was conducted with parrots that were previously kept as pets to determine changes in feather plucking behaviour (Lumeij and Hommers, 2008). Data showed that plumage condition improved in most individuals during the pipe-feeding phase. Authors also found that birds that received the control phase (non-functional pipes) after the pipe feeding period used the feeders as a toy. This may

suggest that play could be a behavioural need fulfilled by the devices. Van Zeeland and colleagues (2013) evaluated eleven devices in terms of foraging times. Overall, all tried enrichments increased foraging times. Devices based on modifications to food extraction and processing resulted in greater food consumption. Habituation is sometimes a concern with environmental enrichment but after seven days there was no evidence of reduced foraging patterns.

Two experiments (Rozek et al., 2010; Rozek and Millam, 2011) analysed the effect of food size on foraging times. Rozek and collaborators (2010) offered parrots one of two diets: regular pellets or regular and oversized pellets. Two wooden cubes were located on the walls of the cages to determine pellet removal in their presence. Oversized pellets increased the time between feeder visits and the amount of food manipulations with feet and beak when compared to only regular pellets. The presence of wooden cubes did not affect food consumption. Rozek and Millam (2011) repeated the experiment but using two larger sizes of pellets. Diet was now provided in a feeder with weights on the access lid. Pellet size had an effect on the maximum paid price (*i.e.* weight lifted) to access the cubes. Like previous research (Rozek et al., 2010), parrots preferred pellets of the largest available size and cubes were preferred only when regular pellets were available.

#### **2.2.5 Mixed enrichment**

Twelve articles were not classified under any of the above categories as their methods involved multiple enrichment protocols (one study had a subset of parrots in which social effects were analysed separately from other enrichment protocols, see 2.2.2). The most common scenario, with seven references, was the provision of both physical and foraging enrichment. Garner et al. (2006) provided these during an experiment on abnormal behaviours in Amazon parrots. Their results only described the amount of time spent stereotyping for unenriched birds (showing a similar range to that of the whole population). Conclusions stated that abnormal behaviours were negatively correlated to the number of neighbouring birds but the effects of the physical and foraging opportunities were not discussed. Van Hoek and King (1997) observed that parrots with visible plumage damage were significantly more stationary and performed more preening, allopreening and other intra-pair activities than birds without this problem. Providing toys, perches and food enrichment together was more effective than when provided separately. This was evidenced by a decrease in preening and an increase in food and toy manipulations and locomotor behaviours. While feather problems did not

disappear, they did stabilise during the experiment. A long term, multi-study experiment analysed the effects of foraging and physical enrichment on psittacine exploration (Meehan and Mench, 2002), feather picking (Meehan et al., 2003b) and stereotypical behaviour (Meehan et al., 2004). Enriched parrots showed a decrease in fear responses to objects and humans (Meehan and Mench, 2002), an improvement in feather score (Meehan et al., 2003b) and spent less time performing stereotypic behaviours (Meehan et al., 2004). Fox and Millam (2007) measured neophobic responses under high and low novelty treatments, finding that birds in the high enrichment category showed shorter latencies to approach novelty. However, this treatment was not as effective in the most fearful birds. De Andrade and de Azevedo (2011) found a non-significant decrease in stereotypical behaviour following a pre-enrichment, enrichment and post-enrichment regime. Since interaction with enrichment was grouped with “other” behaviours in their data collection, further analyses to specifically assess enrichment exploration should take place.

Three studies analysed enrichment based on physical and social manipulations. Millam et al. (1994) housed parrots in groups and then re-grouped them as breeding pairs. For the first year, eight pairs were provided a variety of enrichments (e.g. pair separation, misting, fruit variety, covered nest holes and larger nest boxes). The following year, previously enriched birds were relocated and former controls were grouped as same-sex flocks and then re-paired. Egg laying was found to be positively affected by enrichment opportunities (controls from the first trial laid eggs when they were enriched in the second phase). Luescher and Sheehan (2005) provided different rearing environments for parrots. Chicks were moved into plastic tubs and allocated into one of four treatments: enriched environment and supplementary daily handling; enriched environment with no extra handling; restricted environment and extra handling; and restricted environment with no extra handling. Enrichment conditions involved being housed with a conspecific, brightly-coloured tub sides and a set of 20 toys. Novel object, novel conspecific, open-field, handler response and learning tests were implemented to measure exploration, fear and behaviour. Conclusions indicated that enrichment and handling resulted in a significant decrease of fear responses. Polverino et al. (2015) treated parrots with one of three conditions: pairs in small cages, pairs in large cages or social housing in large cages. Stereotypic behaviour and self-preening had higher frequency and duration in parrots with small cages and limited social interaction.

Cussen and Mench (2015) studied the link between enrichment, behaviour and personality of Amazons. Parrots were exposed to enrichment in the form of objects, feeders and human interaction. Results showed a decrease in feather condition and an increase in stereotypy duration in the unenriched setup. However, results varied at the individual level and this was explained in terms of personality: “more extraverted parrots had smaller increases in the proportion of active time they spent engaged in locomotor stereotypy”.

The relationship between feather plucking, enrichment and pharmacology was analysed by Telles et al. (2015) with juvenile parakeets. One group was provided with physical, foraging and sensory enrichment while a second group was treated with haloperidol. After obtaining baseline and experimental behaviour data, it was observed that the parakeets in the enriched group had seen a greater improvement in feather condition compared to the haloperidol group. Enriched birds also performed more species-specific behaviours and were more active during observation periods.

INSERT TABLE 1 HERE

Table 1. Summary of methods, variables and conclusions of enrichment studies on psittacine birds.

### **3. The future of psittacine enrichment**

Table 1 summarises relevant parameters of the reviewed experiments. Published research focuses on analysing options to diversify foraging strategies, determining object preferences or measuring changes in exploration. Orange-winged Amazons are the most represented parrots with 13 out of 23 studies using them as subjects. Research on psittacine well-being concentrates on analysing its effects on abnormal behaviours, including stereotypies and feather picking. Four references did not include conclusions based on welfare indicators since their aim was to investigate preferences. Variables such as sample size and experiment duration also presented high variability among experiments, which complicates results comparisons. Two cases were found in which enrichment protocols were studied for one year or longer. This is comparable to the duration of enrichment studies with rats, where only 11% of reviewed articles involved this timeframe (Simpson and Kelly, 2011). Only two studies explored enrichment opportunities in zoological environments. It is likely that zoo research is less prominent because of complications in controlling environmental variables. Also, enrichment provision in zoos is “opportunistic and reliant on the enthusiasm and persistence of highly motivated keepers” (Mellen and MacPhee, 2001). Literature on psittacine enrichment is dominated by



studies in which two or more enrichment types are provided. Research on sensory enrichment for parrots is completely non-existent. Clark and King (2008) reviewed olfactory enrichment studies in zoos and found 46% of research was undertaken on large felids, followed by primates, reptiles and canids with a smaller representation, discussing that these efforts are targeted towards charismatic species.

Parrot intelligence, suggested to be similar to that of great apes and marine mammals (Kalmar et al., 2007), has triggered an increase in research on these species, particularly African grey parrots and kea (Kalmar et al., 2010). Studies with kea have analysed tool use (Auersperg et al., 2010, 2011a, 2011b), object manipulation (Werdenich and Huber, 2006; Liedtke et al., 2011, Gajdon et al., 2013), cooperation (Tebich et al., 1996) and lock-opening (Miyata et al., 2011). Alex, the African grey parrot, received great attention because of his cognitive and communicative abilities (see Pepperberg, 1999 for an overview on Alex and other conspecifics). These experiments were not included as enrichment efforts in section 2.2 because their goal was to explore the capacities of the tested parrots with no emphasis on well-being or captivity. However, the devices and training procedures used could be considered a form of enrichment. Some of Pepperberg's methods did not involve food as a reward; therefore, they may be classified as occupational enrichment. However, it is necessary to establish any positive effects on the subjects' well-being before reaching this conclusion (see Clark et al., 2013 and Clark and Smith, 2013 for evaluations of enrichment with non-food rewards for dolphins and chimpanzees).

Bauck (1988) discusses how psychology labs pioneered the use of machines for feeding purposes, considering them enrichment precursors. He further states how toys are now common enrichment tools. Enrichment studies have evolved from laboratory comparisons between barren and complex environments to the provision of cognitive tasks. Clark (2011) makes an interesting suggestion for zoological institutions with regard to enclosure design. She proposes a "high-investment approach to cognitive enrichment" in which animals would have access to separate areas with different tasks. The use of technology can be of help to provide enrichment (Pepperberg (2004) provides a descriptive overview of technological developments that could facilitate enrichment).

The well-being of parrots living as human companions may be challenging to assess due to differences in housing conditions. Lantermann (1997) surveyed 258 parrot owners, discovering only a

small number of these birds were housed under favourable conditions. Educating owners about appropriate ways to keep parrots is one solution for this problem. For example, Avian Studios© ([www.avianstudios.com](http://www.avianstudios.com)) has developed a series of educational videos directed towards bird owners in which housing, nutrition and diseases are discussed. A separate volume explains environmental enrichment based on natural foraging instincts.

#### **4. Conclusion**

Giving enrichment to parrots has been shown to have an effect on their activity budgets. Avian behaviour is generally divided into foraging, socialisation, grooming and resting (Echols, 2010). Echols proposed that when one of these categories is reduced in captivity the others increase, leading to behavioural abnormalities like excessive preening. This theory does not explain other abnormal behaviours such as stereotypies, as “locomotion” is missing from the behavioural groups. Thus, these categories may need to be reassessed to fully encompass parrot behaviour. Play behaviour should also be considered given its prevalence in parrots (see section 1). Some enrichment studies have included objects that could trigger object play (see section 2.2). As discussed by Shepherdson (2010), we have to keep in mind that a behavioural change following enrichment provision does not necessarily equate to improved well-being.

Because of farmers’ interests, better control of their animals and the influence of public opinion, studies in farm settings have examined the link between enrichment and well-being with more indicators. Zoo research has shown that enrichment is useful to decrease the frequency of stereotypes (Swaigood and Shepherdson, 2006). However, more welfare indicators such as body weight, affective state and hormone levels, should be investigated in zoological collections. Work on psittacine enrichment and exploration has already been carried out but there is still much to be done to discover which specific enrichment characteristics cause animals to explore (Mench, 1998).

I share Mellen and MacPhee’s (2001) belief that enrichment is not something that can be defined easily for all species. They suggest that natural history (also commented by Mench (1998)); individual history and exhibit characteristics should be considered when designing an enrichment protocol. It has been found that parrots’ environment and diet are correlated to exploration and neophobia (Mettke-Hoffman, 2002). Some studies looked into reducing neophobia (see Table 1) but one should ask if this behaviour is of biological significance for parrots (Clark and King (2008) discuss that

neophobia might be an appropriate enrichment response). Perhaps this should only be acceptable in highly explorative species such as the kea. Besides being of biological relevance, enrichment should include appropriate challenges (Kalmar et al., 2010) to promote well-being. These challenges should allow animals to have a degree of control on their environment (Swaigood and Shepherdson, 2005).

Environmental enrichment can also be of benefit for wildlife conservation. Millam's (1994) work with parrots has shown an effect of enrichment on parrot sexual activity, which could be useful for species in need of captive breeding (for example Spix's macaws). Shaping certain behaviours with enrichment is also helpful to increase the post-release success of captive wildlife (Watters and Meehan, 2007; Reading et al, 2013).

### **Acknowledgments**

The author thanks Mike Mendl, Anna Egerton and John Hatzakis for their constructive feedback on an earlier version of this manuscript. This article was written while being funded by Consejo Nacional de Ciencia y Tecnología (CONACYT, México) with grant number 400265.

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<b>Species and sample size (number of parrots)</b>	<i>Amazona Amazonica</i> (21)	<i>A. Amazonica</i> (19)	<i>A. Amazonica</i> (64)	<i>Ara ambiguus</i> (2) and <i>Ara chloropterus</i> (2)	<i>Trichoglossus ornatus</i> (14), <i>Charmosyna josefinae</i> (10), <i>Charmosyna pulchella pulchella</i> (12), <i>Psephotus dissimilis</i> (14), <i>Trichoglossus haematodus moluccans</i> (12), <i>Psephotus varius</i> (14), <i>Neopsittacus pullicauda</i> (14), <i>Charmosyna papou goliathina</i> (14), <i>Northiella haematogaster</i> (14), <i>Psephotus haematonotus</i> (14)	<i>A. amazonica</i> (8 – 10)	<i>A. amazonica</i> (12)
<b>Subjects' origin</b>	Captive born, parent-raised, wild-caught parents	Captive born. Rearing conditions as part of experiment	Captive born, wild-caught parents	Captive born. Female <i>A. chloropterus</i> rearing unknown, rest parent reared	NA	Four parent-raised birds, six hand-reared	Eight hand-raised, four parent-raised
<b>Study duration</b>	12 months	12 months	NA	15 weeks	2 days	>13 days	57 days
<b>Captive environment</b>	Laboratory	Laboratory	Laboratory	Zoo	Laboratory	Laboratory	Laboratory
<b>Enrichment provided</b>	Conspecific companionship	Different rearing environments: parent-reared, parent-reared with human interaction or human-reared	Foraging and physical enrichment (not described), neighbouring conspecifics	Behavioural training for artificial insemination procedures	Novel objects: rope, cotton mop and three small blue plastic tiles	Wooden and rawhide cubes of different colours	Rope of different colours and sizes
<b>Well-being measure</b>	Stereotypy development, feather plucking, fearfulness and aggression	Latency to feed and fearfulness	Stereotypies and feather picking	Behavioural activity, stereotypies	Latency to touch novel object, number of objects touched and duration of exploration	Measured preferences for enrichment characteristics	Measured preferences for enrichment characteristics
<b>Well-being conclusion</b>	Pair housing results in: more active and diverse behaviours, hindered stereotypy development, modifications to fear responses	Hand-reared birds less neophobic until 6 months of age. At 1 year of age, all groups showed similar levels of neophobia	Parrots with more neighbours showed less stereotypy, could not assess enrichment as a variable due to study design, proximity to a door associated with feather picking	Training did not result in stress or affected reproductive behaviours of both <i>A. ambiguus</i> . Female <i>A. chloropterus</i> stressed, probably due to training and/or external factors. Male <i>A. chloropterus</i> did not complete training.	Resident species showed earlier exploration; exploration positively correlated with feather-plucking	Not explicitly; suggest further studies examining the biological basis of preferences to improve welfare	Not explicitly; results could serve as guidelines for enrichment device development; suggest that devices' properties may trigger different motivation behaviours
<b>Reference</b>	Meehan et al., 2003a	Fox and Millam, 2004	Garner et al., 2006	Leblanc et al., 2011	Mettke-Hoffman, 2000	Kim et al., 2009	Webb et al., 2010

<b>Species and sample size (number of parrots)</b>	<i>Ara rubrogenys</i> (4), <i>Rhynchopsitta pachyrhyncha</i> 2), <i>A. chloropterus</i> (2) and <i>Lorius garrulus</i> (2)	<i>Psittacus erithacus</i> (18)	<i>P. erithacus</i> (12)	<i>A. amazonica</i> (30)	<i>Pyrrhura perlata perlata</i> (10)	<i>A. amazonica</i> (16)	<i>A. amazonica</i> (16)	<i>A. amazonica</i> (16)
<b>Subjects' origin</b>	NA	Former pets	Ten parent-raised, two hand-raised	NA	NA	Captive-born. Parent-raised, hatched from wild-caught pairs	Captive-born. Parent-raised, hatched from wild-caught pairs	Captive-born. Parent-raised, hatched from wild-caught pairs
<b>Study duration</b>	102 hours	2 months	>12 weeks	2 years	24 weeks	1 year	48 weeks	48 weeks
<b>Captive environment</b>	Zoo	Laboratory	Laboratory	NA	Zoo	Laboratory	Laboratory	Laboratory
<b>Enrichment provided</b>	Length of wood with two variations in food distribution.	Pipe feeders	Foraging enrichment	Pair separation, misting, fruits, nest hole restriction and larger next boxes	Foraging enrichment, addition of perches	Increased cage physical complexity and provided foraging enrichment	Increased cage complexity and provided foraging enrichment	Increased cage complexity and provided foraging enrichment
<b>Well-being measure</b>	Measured preference on enrichment's food supply	Feather picking	Studied effects on foraging activity	Egg laying	Feather picking	Responses to novelty and human handlers	Feather picking	Development of stereotypic behaviours
<b>Well-being conclusion</b>	Suggest increasing foraging opportunities successful as enrichment; induced more appropriate species-specific behaviours	Pipe feeder increased foraging time and feather condition	Not explicitly; foraging enrichment can increase foraging times	Parrots' sexual activity stimulated by enrichment protocols	Stabilisation of plumage problems during study, natural and edible materials more successful	Enrichment reduced fear and motivation for environmental interaction	Decreased feather picking	Stereotypies nearly prevented through their enrichment protocol
<b>Reference</b>	Coulton et al., 1997	Lumeij and Hommers, 2008	Van Zeeland et al., 2013	Millam et al., 1994	Van Hoek and King, 1998	Meehan and Mench, 2002	Meehan et al., 2003b	Meehan et al., 2004

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<b>Species and sample size (number of parrots)</b>	<i>Nandayus nenday</i> (48 test subjects and 27 as social enrichment)	<i>A. amazonica</i> (34)	<i>A. amazonica</i> (6-12)	<i>A. amazonica</i> (10)	<i>Aratinga leucophthalma</i> (10)	<i>Melopsittacus undulatus</i> (36)	<i>A. amazonica</i> (13)	<i>Aratinga leucophthalma</i> (12)
<b>Subjects' origin</b>	Taken from nest box at about 2 weeks of age	Captive-born. Twelve hand-reared, 22 parent-reared	Captive-bred	Captive-bred	Rescued animals	Descendants of cage-bred individuals for exhibition purposes	Captive bred, chicks parent-reared with human interaction	NA
<b>Study duration</b>	6 weeks	25 weeks	>4 weeks	7 months	7 months	8 months	40 weeks	3 weeks
<b>Captive environment</b>	Private aviary	Laboratory	Laboratory	Laboratory	Rehabilitation centre	Laboratory	Laboratory	NA
<b>Enrichment provided</b>	Physical enrichment, handling by humans, social enrichment	Foraging devices and toys	Foraging enrichment	Foraging enrichment	Foraging enrichment	Physical and social enrichment	Variety of physical foraging and social enrichment by handlers	Several items for sensory, foraging and physical enrichment
<b>Well-being measure</b>	Novel object, novel conspecific, open field, emergence, latency to feed, learning tests and behavioural assessment	Novel object test	Behavioural analysis, pellet preference	Motivation for pellet types, destructible cubes, contrafreeloading, podomandibulation	Behavioural analysis	Behavioural analysis	Development of abnormal behaviours	Feather picking
<b>Well-being conclusion</b>	Protocols reduced fear levels and increased exploration in some tests	Rotation of devices more effective than enrichment itself to reduce fear	Oversized pellets made foraging times similar to wild activity, parrot appetites motivated by food form	Parrots exhibit motivation to perform naturalistic behaviour; link with welfare not clear	Reduced abnormal behaviours non-significantly	Stereotypies reduced when birds allowed to interact with multiple social partners	Deprivation of enrichment decreased feather condition and increased time spent stereotyping	Environmental enrichment more effective in treating feather picking when compared to drug treatment
<b>Reference</b>	Luescher and Sheehan, 2005	Fox and Millam, 2007	Rozek et al., 2010	Rozek and Millam, 2011	de Andrade and de Azevedo, 2011	Polverino et al., 2015	Cussen and Mench, 2015	Telles et al., 2015

Species and sample size (number of parrots)	<i>Amazona Amazonica</i> (21)	<i>A. Amazonica</i> (19)	<i>A. Amazonica</i> (64)	<i>Ara ambiguus</i> (2) and <i>Ara chloropecterus</i> (2)
Subjects' origin	Captive born, parent-raised, wild-caught parents	Captive born. Rearing conditions as part of experiment	Captive born, wild-caught parents	Captive born. Female <i>A. chloropecterus</i> rearing unknown, rest parent reared
Study duration	12 months	12 months	NA	15 weeks
Captive environment	Laboratory	Laboratory	Laboratory	Zoo
Enrichment provided	Conspecific companionship	Different rearing environments: parent-reared, parent-reared with human interaction or human-reared	Foraging and physical enrichment (not described), neighbouring conspecifics	Behavioural training for artificial insemination procedures
Well-being measure	Stereotypy development, feather plucking, fearfulness and aggression	Latency to feed and fearfulness	Stereotypies and feather picking	Behavioural activity, stereotypies
Well-being conclusion	Pair housing results in: more active and diverse behaviours, hindered stereotypy development, modifications to fear responses	Hand-reared birds less neophobic until 6 months of age. At 1 year of age, all groups showed similar levels of neophobia	Parrots with more neighbours showed less stereotypy, could not assess enrichment as a variable due to study design, proximity to a door associated with feather picking	Training did not result in stress or affected reproductive behaviours of both <i>A. ambiguus</i> . Female <i>A. chloropecterus</i> stressed, probably due to training and/or external factors. Male <i>A. chloropecterus</i> did not complete training.
Reference	Meehan et al., 2003a	Fox and Millam, 2004	Garner et al., 2006	Leblanc et al., 2011



## AUTHOR DECLARATION TEMPLATE

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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Rogelio Rodríguez-López  
09/10/2015